of a homographic range, then the two rows are congruent, it is necessary and sufficient that the distance between two elements a, b is $\kappa \log (abij)$, where κ is a constant and $(abij)$ is the cross-ratio of a, b, i, j, the last two being two fixed elements on the "line" ab, the so-called absolute point-pair of the line. This leads to Cayley's theory of the absolute quadric, and the classification of metrical geometry into the three kinds, elliptic, parabolic, and hyperbolic. The theory of angles between lines or planes, the theory of parallels, and the general definition of perpendicularity follow in due course. In all this there is no hocus-pocus whatever; we have an analytical theory, based upon precise definitions, which is quite independent of any appeal to the senses. But the question is bound to arise: "What is the relation of this to real geometry? What has it to do with the space of which we have experience, with the practical measurements which we are making every day?" To answer this inquiry in anything like a satisfactory way it is necessary to clear our mind of prejudices and misconceptions which obscure the whole matter until they are removed.

First of all it must be remembered that we cannot distinguish between real and imaginary space in the same sense as we do, for instance, between a real experience and an hallucination, or between a photograph and a landscape composition. Space is *essentially* an ideal conception, and strictly speaking we have no experience of space at all; we evolve, each of us probably with his own degree of precision or vagueness, a scheme to which we relate certain aspects of our sense-impressions. To attempt to define real space as the space in which real things exist is, of course, mere playing with words and avoiding the true issue: when we say that a thing "exists in space," we refer an actual (or imagined) objective experience to an ideal scheme, and our statement has a meaning for us simply so far as the scheme is clearly developed *in subjecto*. Again, to say that real space is of three dimensions, as contrasted with the n-dimensional space of abstract analytical geometry, merely means that, hitherto, a three-dimensional scheme has proved sufficient for the classification of those sense-impressions which admit of a spatial interpretation. It is a very interesting experiment to walk along a street and attend exclusively to one's visual impressions; this gives a consistent experience of a *two*-dimensional space with a time-series of continuous projective transformations. The exhibitions of "animated photographs" afford a similar experience; the conclusion seems obvious that the properties of "real" space are conditioned by the range of sensations that we refer to it. Supposing that we could develop a new sense, it is quite possible that we might experience a "real" space of four dimensions.

From the purely mathematical side these discussions are more or less irrelevant. The definition of a positional manifold of n dimensions is perfectly clear and intelligible; and it is quite legitimate to assume such postulates of construction as will make the corresponding geometry just as much a true geometry as the elements of Euclid. Of course, if $n>3$, we lose the help of "intuition," that is, the suggestions of sense-impressions; but these suggestions are not essential, and the modern development of geometrical theory is, in fact, chiefly due to a sceptical criticism of the crude results of merely objective experience.

Then, again, as to the metrical properties of space. The analytical theory leads, as we have seen, to three distinct varieties. No conceivable experiment can decide whether "real" space is elliptic, hyperbolic, or parabolic: one sufficient reason is that it is pure assumption to suppose that we can move a ruler about without altering its length. It is enough for all practical purposes to know that the hypothesis of parabolic space is comparatively simple, and serves nearly enough for the interpretation of physical measurements. In this connection, special attention may be directed to Mr. Whitehead's notes on pp. 499 and 451. The last is particularly important, as pointing out that a space of one type may be a locus in a space of one more dimension and of a different type: thus ordinary Euclidean space of three dimensions may be regarded as a limit-surface in a hyperbolic space of four dimensions.

On p. 369 will be found a very useful bibliography of treatises and memoirs dealing with the general theory of metrics; one omission that may be noted is that no reference is given to Lie's large treatise on transformation-groups, which contains a section on this subject, with detailed criticism of the theories of Riemann, Helmholtz and others.

It would not be right to conclude this notice without saying a word or two in appreciation of the spirit of thoroughness and of independence in which Mr. Whitehead's valuable book has been written. It possesses a unity of design which is really remarkable, considering the variety of its themes; and the author's own contributions, not only in illustrative detail, but in additions to the general theory, are well worthy of attention. All who are interested in the comparative study of algebra will look forward with pleasurable anticipation to the appearance of the second volume, and wish the author all success in bringing his formidable task to a conclusion.

G. B. M.

EARLY GREEK ASTRONOMY.

The First Philosophers of Greece. An edition and translation of the remaining fragments of the pre-Sokratic philosophers, together with a translation of the more important accounts of their opinions contained in the early epitomes of their works. By Arthur Fairbanks. Pp. vii + 300. (London: Kegan Paul, Trench, and Co., Ltd., 1898.)

THE histories which we possess and to which we readily turn for information concerning the early science of the ancients have been prepared mainly by two kinds of writers, having in view two different objects. We have on the one hand, works like those of Delambre, or in later times of Mr. Narrien, authors possessing a comprehensive knowledge of mathematical analysis, and who, writing for the benefit of physicists, are most interested in exhibiting the scientific connection existing between the older philosophers and modern science. As an example of the other kind, we may refer to such works as that by Sir G. C. Lewis, whose classical attainments were probably in advance of his knowledge of physics, and who looked upon the writings of the ancients from the point of view of a student of ethics and philosophy. He addressed a wider and less specially educated class, whose interest in his book was perhaps more literary than scientific. Neither method of exhibiting the extent of ancient knowledge is free from objection. In either case the original is liable to be coloured or distorted by the views of the commentator. The modern serious student desires to consult original authorities, and takes but little interest in compilations, however thorough, by authorities, however competent. The work of Mr. Fairbanks will therefore be welcome to that class of students, who are anxious to know what the various authors have said themselves, not merely the interpretation which later writers have put upon these utterances. These original sources of information are too often only to be found in short fragments scattered liberally throughout Greek literature in the form of quotations from the earliest writers, or more or less complete epitomes of the masters' teaching, prepared by later writers. German criticism has been busy with these fragments, determining the relation of these writers to each other as well as to the source of the whole series, in order that we may estimate their relative value. The Greek text of these fragments has been published in numerous short monographs, most of which, however, are not easily accessible, and a competent guide is necessary. This essential service Mr. Fairbanks has rendered to the student by placing the materials ready to his hands. He has, moreover, prepared a carefully constructed text, enriched it by critical notes, and added an English translation. Important passages from Plato and Aristotle bearing on these early writers are also given, so that even the better known authorities gain some illumination. Mr. Fairbanks puts before us all the material for the survey of the history of early Greek thought; we necessarily confine our attention to the physical side.

It is interesting to inquire whether the reputations of certain philosophers, and the estimate we have formed of their scientific insight, should be modified by a critical study of the original description apart from the interpretation which later authors have given to these expressions. We are too apt to quote over and over again the expressed opinions of writers of repute, without re-examining the grounds on which those opinions rest. We may unconsciously attach too much weight to the comments of later writers who have been swayed by tradition, and who, in the absence of exact information, drawn from trustworthy sources, have inserted their own views in the place of the original. Unfortunately, in some cases, and these the most interesting, no fresh information is forthcoming. Thales, the founder of the Ionian school, for instance, remains as mythical and unsubstantial as ever. He looms large on the distant background owing to his connection with the famous eclipse to which his name is attached, and the part it has played in scientific chronology, but neither ingenuity nor research seems likely to afford a satisfactory answer to the several enigmas connected with his history. Anaximandros and Anaximenes scarcely fare better. It is generally agreed that two short phrases have been taken directly from the writings of the former, but even admitting the probability, neither of these expressions is calculated to throw much light on his teaching or illustrate any distinctive feature in the cosmical tenets which he propounded. It is not till we come to Herakleitos that we meet with any large number of original extracts. The preservation of these quotations may be due to chance, or may be held as evidence of the greater veneration in which his teaching was held. The student of Plato is acquainted with a few of his sayings which had passed into the character of proverbs, and attest the popularity of the author The complete collection presented to us by Mr. Fairbanks does not appear very edifying. Some, indeed, have the solemnity of the Proverbs of Solomon, while others well maintain that reputation for obscurity which the author early acquired and consistently retained. As an acute observer and scientific teacher, Herakleitos falls far behind Thales, or rather behind the position popularly assigned to Thales, for which, however, we get here little additional support. The suspicion that Herakleitos believed the sun to be no larger than a human foot is confirmed, and it seems probable that he taught that the sun and moon were both bowl-shaped. Eclipses were produced by the turning of these bowl-shaped bodies, so that the concave side was turned upwards and the dark convex side was seen by the observer. Following, however, the reconstructed "Placita of Aetios," probably the original work from which both Stobaeos and Plutarch copied, the earlier master taught that the eclipses of the sun took place when the moon passed across it in direct line, and that eclipses of the moon proved that it came into the shadow of the earth: the earth coming between the two heavenly bodies and blocking the light from the moon. Whether Thales really taught these advanced views himself is immaterial; the fact remains that these correct notions did obtain at a very early date, and it is very difficult to understand how, in any enlightened society, they were supplanted by the childish formulas recited by Herakleitos and his admirers. The scientific teaching of the school of Thales seems to have been at its best at its birth and to have rapidly deteriorated, authority possibly usurping the place of observation.

The Eleatic school, however, had much to learn. Xenophanes, the founder, was not happy in his scientific suggestions. According to the authority just quoted, this philosopher taught that the stars were formed of burning cloud, extinguished each day and re-kindled at night. This seems to be a fair sample of his teaching, and his name and his work may be rapidly passed aside. Parmenides, probably the disciple of Xenophanes, is entitled to more respectful consideration, both by reason of the regard in which he was held by Plato and by the correctness of his views on certain scientific points. From a passage in Stobaeos he has been credited with having taught that the earth was spherical in shape, but some doubt has existed, inasmuch as the same writer attributes the same discovery to Anaxagoras. Modern research seems to declare on the side of Parmenides, but the evidence is by no means clear.

Other teachers come under review, notably Pythagoras, from whom we have no preserved quotation, though the doxographists have much to say of him, and of Empedocles, who has much to say, both in his own words and those of others. But the reading of even the longest extracts does not leave a very satisfactory impression. It is impossible to feel that the quotations that have been preserved are those that are most characteristic of the master, or those by which he himself would wish to be judged. Some happy expression, some lucky chance may have attracted the attention of a pupil or a commentator, with the result that we get transmitted to us a very imperfect view, and consequently we utterly fail to reconstruct any adequate picture of the philosophical teaching as a whole. If Plato, writing of Parmenides, almost a contemporary, could say "I fear lest we may not understand what he said, and that we may fail still more to understand his thoughts in saying it," how much more difficult is it for us to obtain a clear conception. But this difficulty does not detract at all from the value of Mr. Fairbanks work, or of those who have laboured in the field of literary criticism. In entering into their labours we learn with clearer precision the extent and the trustworthiness of the materials that exist for the study of early Greek thought.

A HUNDRED AND FIFTY NORTH AMERICAN BIRDS.

Bird Neighbors: an Introductory Acquaintance with One Hundred and Fifty Birds commonly found in the Gardens, Meadows, and Woods about our Homes. By Neltje Blanchan; with Introduction by John Burroughs. Pp. viii + 234. Coloured plates. (London: Sampson Low, Marston, and Co., Ltd., 1898.)

AT the first glance this volume might well be mistaken for an addition to the already extensive literature relating to British birds; but the spelling of the second word in its somewhat cumbersome title at once proclaims its Transatlantic origin. And, as a matter of fact, it is really a popular account of some of the commoner birds of the United States. Since it is confessedly printed in New York, it is doubtless an English edition of a work first published in the States; and although it may be most useful in the land of its birth, we may perhaps be permitted to suggest that it would have been better had its issue been restricted to that country.

On first opening the book the reader is confronted with a frontispiece purporting to represent the "Goldfinch," but instead of seeing the bird properly so denominated, he finds the so-called American Goldfinch (*Spinus tristis*). And, although the bird's proper title is given in the text, the plate, for issue in this country, ought to have been similarly lettered. This is by no means a solitary instance as regards the legends to the plates; while in the systematic part it is even worse. We find, for instance, the Hangnests, or *Icteridæ*, popularised under the names of blackbirds and orioles; while in the family (*Turdidæ*) to which the birds properly so-called belong, we have, in addition to thrushes, bluebirds and robins. Doubtless this is good enough for a country in which bison are miscalled buffalo, and stags of the red deer group elk, but it will scarcely commend itself to English readers.

In her preface the lady author lays great stress on the circumstance that "her knowledge has not been collected from the stuffed carcasses of birds in museums [as if any one examined *stuffed* specimens for descriptive purposes], but gleaned afield." And in the introduction it is written:—"The pictures, with a few exceptions, are remarkably good and accurate, and these, with the various groupings of the birds according to colour, season, habitat, &c., ought to render the identification of the birds, with no other weapon than an opera-glass, an easy matter."

It would be distinctly interesting to know which were the exceptions above referred to. Was the plate of the Yellow-throated Vireo, facing p. 189, one of them? In this plate we have an obviously stuffed example (and not a very well stuffed one at that) of the bird in question, mounted upon one of the conventional museum perches. The bird thus mounted has been fixed in the most glaringly obvious manner to one of a series of twigs of apple in blossom, and the whole reproduced as a picture. Apart from the perch, the general effect might not have been utterly bad, were it not that the twigs are placed in the vertical when they should have been in the horizontal position.

But there are even things artistically worse than this. Many of the plates, such as those of the Bobolink and the Brown Thrasher, appear to have been produced by taking a landscape and placing in front of it either a single (apparently stuffed) bird or a group of birds, and then, by some process unknown to us, reproducing the whole. And the effect is not pleasing. Either the objects in the background stand out as though they formed the middle distance, or they are hopelessly out of focus and form a confused blurr. As already said, the author inveighs against stuffed "carcasses," but if the Blackcap-Tit, or "Chickadee," forming the subject of the plate facing p. 76, does not come under such designation, we shall be greatly surprised.

Neither can we commend the arrangement of the birds described. At the commencement of the book these are placed under their proper families, and to our thinking no better arrangement could have been followed in the sequel. But this by no means suits the author. And after a little preliminary skirmishing in the way of classing by habitats, season, and size, she finally settles down to arrange the species by coloration! Consequently we have closely allied forms widely separated, and incongruous species placed in juxtaposition, without, so far as we can see, one single advantage gained over the ordinary system. To take an example, we have two species of woodpeckers placed among birds "conspicuously black and white," where they are flanked on each side by a passerine, but a third woodpecker (the "flicker") finds a far distant place among "brown, olive, or greyish-brown, and brown and grey sparrowy birds." Surely this is making confusion for confusion's sake.

Much more sympathy may be expressed for the author's attempt to divide the birds of New York according to whether they are permanent residents, or make their appearance at particular seasons only; and this list may prove of use not only to the ordinary bird-lover, but likewise to the student of migration and distribution. As regards the descriptions of the different